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Diode-pumped 22-W average-power uv laser with user-selectable pulse width and >50% conversion efficiency

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Abstract: A diode-pumped Nd:YAG laser (39 W at 1064 nm) has been frequency tripled with >50% conversion efficiency (22 W at 355 nm). The laser operates at 300 Hz with pulse energies >73 mJ.

OCIS codes: 140.0140, 140.3280, 140.3480, 140.3530, 140.3580.

1. Introduction

Diode-pumped, high-average-power uv lasers typically operate in the multi-kHz regime with pulse-widths on the order of 10 ns. Recent experiments [1] have shown that the bulk damage properties of KD*P (deuterated KD_2PO_4) frequency conversion crystals can be greatly improved by conditioning with uv (~350 nm) laser pulses with pulse widths between 300 ps and 1 ns. Because the time required to condition these crystals is inversely proportional to the average laser power; higher average laser power leads to shorter process times. In addition, as the difference between conditioning and damage is small, the conditioning fluence for each laser pulse and the spatial profile of each laser pulse must be very well controlled. We have built a laser that meets these conditions and we have obtained 22 W of average power at 355 nm.

2. Experiment

In order to meet the stringent requirements for conditioning KD*P crystals, we have chosen a diode-pumped Nd:YAG MOPA (master oscillator power amplifier) design. The oscillator is based on a single-frequency cw fiber laser. This cw signal is temporally chopped and shaped using a dual input fiber modulator. The pulse width is precisely controlled by a Picosecond Pulse Labs programmable pulse generator while the pulse shape is controlled by a specially designed ACSL (aperture coupled strip line) [2]. The resultant shaped output pulse is injected into a diode-pumped regenerative amplifier and boosted to ~2 mJ. The output pulse of the regenerative amplifier is expanded, passed through a serrated aperture and injected into a relay-imaged, 4-pass, diode-pumped amplifier as shown in Fig. 1.

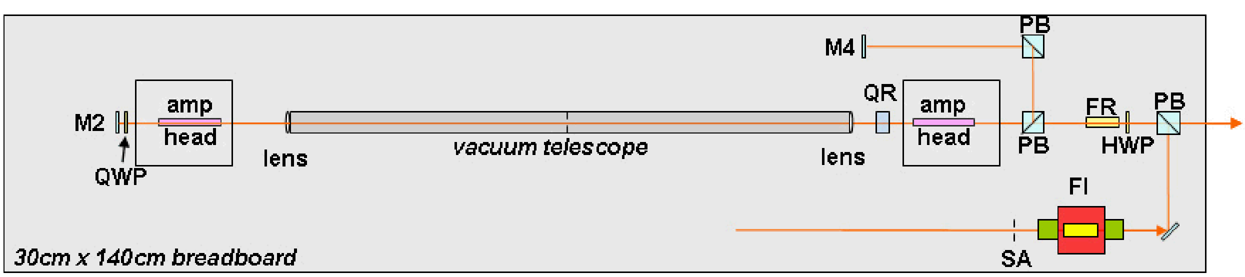

Figure 1. Schematic of the 4-pass, diode-pumped, relay-imaged amplifier.

Two identical diode-pumped Nd:YAG amp heads are separated by a vacuum telescope that act to relay image the serrated aperture (SA) onto high reflector (M2), then onto high reflector (M4), back onto M2 and then onto an output relay plane to the right of the right-most polarizing beam splitter (PB). A quartz rotator (QR) assists in birefringence compensation and a quarter wave plate (QWP) allows four-pass operation of the amplifier. A Faraday isolator (FI) protects the regenerative amplifier and a Faraday rotator (FR) half wave plate (HWP) combination separates the input and output beams. Relay imaging planes outside the amplifier differs from [3] and allows us to 4-pass the amplifier and place a good quality beam into the frequency converter without intervening formatting opics. The frequency converter is located at the output relay plane. Since the output beam is well polarized we have chosen a Type II – Type II frequency conversion scheme as shown in Fig. 2.

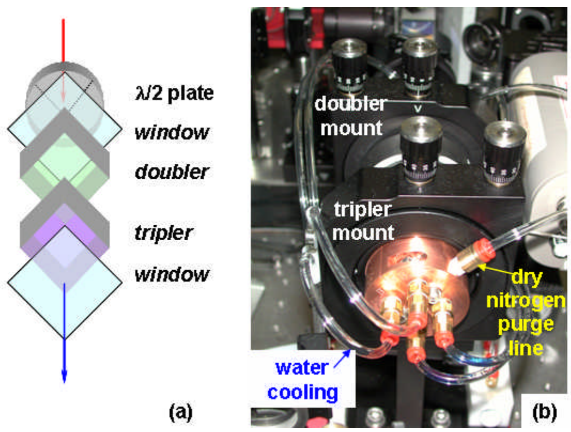

Figure 2. A schematic (a) and photograph (b) of the frequency converter.

The crystals are thermally stabilized using water-cooled copper blocks and the volume between the crystals is purged with dry nitrogen. The tuning angles are adjusted using gimbal mounts. The doubler material is BBO and the tripler material is KD*P. Running at 300 Hz with 130-mJ pulses at 1064 nm, we obtain 73-mJ pulses at 355 nm. The output pulse width is user-controlled and can be varied between 400 ps and 600 ps.

3. References

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